

CR62
1473

Production Aspects of Pigeonpea and Future Prospects

Laxman Singh¹

Abstract. *The current production of pigeonpea in the semi-arid tropics is principally confined to the Indian subcontinent (particularly India and Myanmar), eastern and southern Africa, and the Caribbean. Except in Australia where extensive commercial production has recently been catalyzed, the cultivation of pigeonpea is practiced by small farmers to meet domestic needs for food (as dry grain, split dhal, and green vegetable), and for animal feed and fuel wood; to produce a marketable surplus for cash income, and to form an important component of intercropping in cereal-based production systems for sustainability, and risk aversion.*

The production is constrained by the current cultivation practices; less productive land-resource allocation, excess water or drought stress peculiar to rainfed agriculture, and losses caused by diseases and pests, and long-duration cultivars of 160-250 days. Other problems are; inadequate support for technology generation and its transfer, the lack of stress-resistant, high-yielding genotypes, agronomic management, new production systems, and lack of utilization research and promotion, both of processed and raw material, for human and animal consumption.

The future prospects for enhanced and sustained production are bright, in that new short-duration cultivars (90-130 days) make pigeonpea amenable to field-scale cultivation as a sole crop in several production systems involving multiple cropping, both under rainfed and irrigated farming systems. New genotypes in the long-duration group with stable resistances to major diseases (fusarium wilt and sterility mosaic disease) are available. They will contribute to the improvement of the traditional intercropping or mixed cropping production system of annual crops, and short-lived perennial to alley and agroforestry systems. However, instability of production under rainfed conditions caused by excess or reduced rainfall, and diseases and pests, still remain major issues for research in the short-duration group of cultivars.

1. Principal Plant Breeder, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, A.P. 502 324, India.

Presently Principal Pigeonpea Agronomist, ICRISAT, C/o OAU/STRC, J.P. 31 SAFGRAD, P.O. Box 39063, Nairobi, Kenya.

ICRISAT Conference Paper no. CP 627.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1991. Uses of tropical grain legumes: proceedings of a Consultants' Meeting, 27-30 Mar 1989, ICRISAT Center, India. Patancheru, A.P. 502 324, India: ICRISAT.

The potential exists to new niches of production systems using short-duration cultivars, provided simultaneous research and development are carried out for appropriate utilization. A quantum jump in productivity could be achieved by using hybrid pigeonpea, new dwarf plant types, biotechnology techniques for introgressing incompatible wild species for germplasm development, and new sources of tolerances to abiotic stresses (drought and salinity) and biotic stresses (insect pests and diseases).

Introduction

The pigeonpea is a member of the subtribe *Cajaninae*, tribe *Phaseoleae*, and family *Leguminosae*. Although it is often stated to be a monotypic genus, van der Maesen (1986) proposed merging of the related species of genus *Atylosia*, whereby *Cajanus* now numbers 32 species. According to him, the Indian subcontinent contains 17 species, Australia 13 species, and New Guinea and West Africa one species each.

Van der Maesen (1980) concluded that evidence points to an Indian origin of the pigeonpea, from where it was most probably distributed to Africa, by two millennia BC at the latest. He also suggested that Africa is a secondary center of origin.

Pigeonpea is inherently a perennial, erect, bushy plant. However, it is also cultivated as an annual crop, with a range of maturity duration from 90 to 250 days. It can grow over 3 m tall, has woody stems, and a long tap root. Plant type and growth habit exhibit wide variation. The angle of primary branches determine the spread of the plant, varying from compact types with acute branch angle, to open types with obtuse branches. The leaves are trifoliate, having lanceolate to elliptic leaflets that are acute at both the ends. The inflorescence is an axillary raceme, varying in length from 4 to 12 cm. The dry seeds vary greatly with respect to their size (100-seed mass 2-24 g), shape (round, oval, or flattened), and color (white, brown, red, purple, or black). The seed coat is smooth, and the cotyledons are light yellow. In general, there is no seed dormancy, and germination is hypogeal.

Pigeonpea is a quantitative short-day plant. Because of its sensitivity to photoperiod and temperature interactions, sowing time and location influence both plant growth and phenology. Short-duration pigeonpea cultivars are less sensitive to changes in daylength than medium- and long-duration ones.

Production and Uses

Pigeonpea grows well in subtropical and tropical environments, extending between latitudes 30°S to 30°N, at elevations from sea level to 2000 m. India accounts for more than 90% of the world's pigeonpea production and area (Table 1). Other major producing countries are Kenya, Uganda, Malawi, Myanmar, Tanzania, Puerto Rico, the Dominican Republic, Venezuela, and the Caribbean islands. Area and production figures are often underestimated because a considerable amount of the crop is grown on homesteads, borders, and hedges, and consumed in rural households as dry grain and green peas. Although little of the crop enters world trade, pigeonpea is the fifth most important pulse crop in the world after bean, pea, chickpea, and broad bean.

Table 1. World area (ha), production ('000 t), and yield (kg ha⁻¹) of pigeonpea¹.

Countries	1980			1987		
	Area (ha)	Production ('000 t)	Yield (kg ha ⁻¹)	Area (ha)	Production ('000 t)	Yield (kg ha ⁻¹)
Bahamas	420 F ²	520 F	1 238	510 F	660 F	1 294
Bangladesh	3 737	2 780	744	2 500	2 000	800
Dominican Republic	14 915	10 331	693	11 769	10 966	932
Grenada	500 F	901	1 802	420 F	630 F	1 500
Haiti	8 500 F	4 000 F	471	8 600 F	4 400 F	512
India	2 731 000	1 757 000	643	3 235 700	2 316 300	716
Jamaica	2 462	2 351	955	1 971	1 813	920
Malawi	125 000 F	84 000 F	672	134 000 F	90 000 F	672
Myanmar	31 277	20 520	656	53 612	36 014	672
Nepal	16 400 F	9 000 F	549	22 800 F	12 400 F	544
Pakistan	2 800 F	1 500 F	536	2 200 F	1 000 F	455
Panama	2 100 F	2 004	954	2 900 F	2 500 F	862
Puerto Rico	6 485	5 216	804	5 100 F	3 400 F	667
Tanzania	36 000 F	22 000 F	611	63 000 F	40 000 F	635
Trinidad and Tobago	1 750 F	3 532	2 018	950 F	1 300 F	1368
Uganda	50 000	26 000	520	54 520	24 950	458
Venezuela	6 624	3 447	520	8 900	5 200	584
World total	3 039 970	1 955 102	643	3 609 452	2 553 533	707

1. Estimates for Kenya not available.

2. F = FAO estimates.

Source: Personal communication by Dr E.A. Kueneman, FAO, Rome.

The crop is most commonly grown for its dry, split seeds (*dhal*), but seeds are also eaten as a green vegetable. In the Caribbean islands (particularly the Dominican Republic and Puerto Rico) the crop is grown primarily for export, and canned green seeds are exported to North America.

Dry seeds and the by-products of *dhal* manufacture, together with leaf and pod residues after harvest, can provide suitable feed for ruminants, which may also browse the standing crop (Whiteman and Norton 1981). Grain, whole pods, and milling trash, suitably processed and mixed with additives, have been proposed as substitutes for soybean and maize in poultry and pig feed (Wallis et al. 1986).

Dry stems of pigeonpea are an important source of fuel in rural India. Average stick yields of 7-10 dry t ha⁻¹ are routinely reported, and yields of 20 t ha⁻¹ from irrigated, short-duration varieties have been reported (ICRISAT 1986). Dry-stem material of pigeonpea is also used for fencing, the construction of thatch roofs, and basket making. In some semi-arid regions of northern India (Haryana), farmers pay half the wages in the form of dried threshed stems for harvesting, threshing, and bagging pigeonpea seed.

The pigeonpea plant is also used as a host plant to rear lac insects. If pruned to prevent flowering, the plants can be maintained as lac hosts for several years.

Cropping Systems

Intercropping

The prevalent production systems for pigeonpea are based on medium- to long-duration (160-250 days) types, and virtual shortlived perennial types. In rainfed agriculture, these cultivars are adapted as components of mixed-cropping or intercropping systems with such crops as sorghum, millets, maize, cotton, upland rice, groundnut, soybean, and root crops. These are proven systems used to maximize stability of agricultural production in central and peninsular India (Rao and Willey 1980). Dryland agriculture is characterized by high variability in the incidence of rainfall; for subsistence farmers at least, stability of production over seasons is a more important consideration than simply pursuing high yields. The characteristics, advantages, and disadvantages of this system are discussed by Willey (1985). Rao and Willey (1980) found a 1:1 or 2:1 proportion of sorghum:pigeonpea in an intercrop quite an efficient system in India, and Kannaiyan et al. (1986) reported maize/pigeonpea intercropping to be a productive system in Zambia. The range of cropping systems involving pigeonpea in India has been summarized by Singh (1980).

The productivity of medium- and long-duration pigeonpeas in the cropping systems mentioned above is not only constrained by high variability of moisture availability in rainfed agriculture (waterlogging, intermittent, and terminal drought), but also by other biotic and abiotic stresses. The biotic stresses of diseases, primarily fusarium wilt and sterility mosaic, localized diseases (witches'-broom, alternaria blight, phytophthora blight, dry root rot, and collar rot) and of pests (primarily the pod borer and the podfly and localized sporadic infestations by blister beetles, and pod-sucking bugs) also pose severe constraints to yield.

Short-duration pigeonpeas, just as medium- and long-duration ones can also be intercropped with short-statured grain legumes such as mung bean, urd bean, cowpea, soybean, and groundnut.

The Postrainy-season Crop

In areas where total annual rainfall is > 1000 mm, with wider seasonal distribution of rainfall (e.g., with bimodal distribution), moderate to warm winter temperatures 25-35°C, and deep, moisture-retentive soils, it is possible to sow pigeonpea well after the longest day. This even further widens the flexibility of pigeonpea in being able to fit into various cropping systems. In northeastern India (Bihar and West Bengal) Roy Sharma et al. (1981) and Sengupta (1982) reported 2-3 t ha⁻¹ yields of pigeonpea from Sep-Oct sowings. There is a large potential for growing pigeonpea in rice fallows, considering the area of such land in India, Bangladesh, Myanmar, Sri Lanka, the Philippines, and Thailand.

The Multipurpose Perennial

The multiplicity of uses and perenniality of pigeonpea makes it a good choice for agroforestry systems, as an alley crop, as an intercrop in tree plantations of coconut,

rubber, oil palm, or forest trees, and in resting shifting-cultivation lands. Pigeonpea is widely used as a backyard or garden crop, particularly in Africa and the Caribbean, and also in parts of India and Southeast Asia. Such plants are simultaneously used for their dry grain, and green seeds, and as fodder, construction material, and fuelwood. It is difficult to quantify production in such systems in comparison to field-scale commercial cropping.

Combined resistance to fusarium wilt and sterility mosaic diseases have now been identified in medium- and long-duration pigeonpea with excellent agronomic traits. These cultivars can be grown as perennials for 3-4 years. However, in some regions, diseases, e.g., rhizoctonia root rot, and attack by white ants also constrain perennial pigeonpea production.

Future Prospects

Intensive research efforts on pigeonpea improvement, begun in the early 1970s, have resulted in the development of short-duration genotypes, rendering pigeonpea amenable to field-scale cultivation as a monocrop. Short-duration genotypes permit the use of pigeonpea in double- or multiple-cropping systems, as distinct from their traditional use as a long-season crop. Such cultivars (ICPL 151, Manak, AL 15, UPAS 120) have been adopted in pigeonpea-wheat rotations in wheat-growing regions of India; the pigeonpea is grown during the monsoon period and harvested by November, in time to sow the winter cereal crop.

Being less sensitive to photoperiod and temperature interactions, extra-short-duration genotypes (maturing in 90 days at ICRISAT Center) have the potential to extend the area of adoption of pigeonpea from the equator to 45° latitudes N and S, and higher altitudes. In Sri Lanka in South Asia, and in Trinidad in the Caribbean (both at latitude 8°N), short-duration pigeonpea, when grown at any time of the year, can be harvested for mature pods in 100-120 days, and can also be used for multiple pickings of green vegetable pods or ratooned for multiple dry-grain harvests. The use of short-duration pigeonpea thus ensures that in several regions, vegetable pigeonpea is available all through the year.

In environments with warm winters (minimum temperatures >15°C) in peninsular India, the perennial characteristics of short-duration pigeonpea were exploited by ratooning. Chauhan et al. (1987) reported that this system gives much higher yields than the traditional medium-duration genotypes grown in this environment over a similar time period. A short-duration cultivar, ICPL 87, with good ratoonability was released in India in 1986, and is becoming increasingly popular with farmers.

Short-duration and short-statured (1.0 to 1.5 m) pigeonpea are amenable to mechanization, which had been a goal of pigeonpea research in Australia (Wallis et al. 1981). The potential to mechanize is also an important consideration in the improvement of traditional agricultural systems in Africa and the Caribbean. In India, farmers in addition to using animal power for cultivating short-duration pigeonpea have increased usage of threshers, hitherto not used for traditional long-season types.

With the availability of shorter-duration genotypes (< 100 days at latitude 17°N, ICRI-SAT Center) there is scope for extending pigeonpea to drier environments in the subtropics, to temperate climates up to 45° latitudes N and S, and higher altitudes, where they

reach maturity before the onset of severe drought stress and killing frosts. Breeding and selection at ICRISAT Center of short-duration genotypes with large, white seeds, and large pods have also provided options for their use as vegetable types (Jain et al. 1981), provided problems inherent in such a system e.g., those posed by insect pests could be overcome. This could facilitate development of facilities to process and can vegetable pigeonpea, as a viable option in more tropical environments where garden pea does not grow well. A determinate plant type with synchrony of bearing has advantages for a mechanized production system, while either determinate or indeterminate types with good ratoonability would be suitable for multiple harvesting in small-farm fresh vegetable production systems.

Identification of genetic male sterility, and ICRISAT's studies on the utilization of hybrid vigor have led to the development of short-duration pigeonpea hybrids, which exhibit considerable heterosis in seed yield over their parents and other control cultivars. A private seed organization is marketing a medium-duration pigeonpea hybrid in India, and several private seed companies are now using genetic male sterile sources developed by ICRISAT for hybrid pigeonpea production. Its future seems promising.

To provide stability of production in both long- and short-duration pigeonpea, genetic resistances to major diseases (single and multiple resistances) have been incorporated in improved cultivars. This development is particularly important in enhancing and sustaining the productivity of traditional and new production systems. Recommended for cultivation are such lines as ICP 9145, a wilt-resistant long-duration type in Malawi; and ICP 8863, a medium-duration wilt-resistant type in Karnataka, India. ICPL 366, a long-duration sterility mosaic disease resistant line is being tested in farmers' fields in Nepal.

Tolerance, or reduced susceptibility to pod borer have been sought by entomologists and breeders at ICRISAT; we now have medium-duration pigeonpeas—ICPL 87088 and ICPL 84060, with considerable field tolerance to this pest. This is a significant development for stability and productivity of long-duration pigeonpea that is usually not protected by insecticidal sprays. Entomologists have also developed procedures and schedules for the judicious use of insecticides to protect short-duration pigeonpea. Research is being conducted on integrated pest management, which is vital for the future prospects of pigeonpea.

The transfer of available technology (on utilization and crop improvement aspects) will be faster if efforts for enhanced production are closely linked with the promotion of multiple uses, linking production with market demand and the requirements of agroprocessing industries. Such integrated research and developmental efforts will catalyze global commercial production of pigeonpea for use as vegetable, grain, fodder, and fuelwood.

References

Chauhan, Y.S., Venkataratnam, N., and Johansen, C. 1987. The agronomy of multiple harvest pigeonpea. Page 234 in Food legume improvement for Asian farming systems: Proceedings of an International Workshop, 1-5 Sep 1986, Khon Kaen, Thailand. (Wallis, E.S., and Byth, D.E., eds.). ACIAR Proceedings no. 18. Canberra, Australia: Australian Center for International Agricultural Research.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1986. Pigeonpea. Pages 177-212, in Annual report 1985. Patancheru, A.P. 502 324, India: ICRISAT.

- Jain, K.C., Sharma, D., Gupta, S.C., Reddy, L.J., and Singh, U.** 1981. Breeding for vegetable-type pigeonpeas. Pages 165-172 in *Proceedings of the International Workshop on Pigeonpeas*, 15-19 Dec 1980, ICRISAT Center, India. vol. 2. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Kannaiyan, J., Reddy, M.S., Mbewe, N.N., Haciwa, H.C., Greenberg, B.C., and Irving, N.S.** 1986. Pigeonpea research in Zambia. Presented at the Workshop on Pigeonpea in Eastern Africa, 8-10 Apr 1986, Nairobi, Kenya. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited distribution).
- Rao, M.R., and Willey, R.W.** 1980. Evaluation of yield stability in intercropping: studies on sorghum/pigeonpea. *Experimental Agriculture* 16:105-116.
- Roy Sharma, R.P., Thakur, H.C., and Sharma, H.M.** 1981. Pigeonpea as a rabi crop in India. Pages 26-36 in *Proceedings of the International Workshop on Pigeonpeas*, 15-19 Dec 1980, ICRISAT Center, India. vol. 1. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Sengupta, K.** 1982. Pigeonpea. Pages 81-86 in *Pulses and oilseeds in West Bengal*. Calcutta, West Bengal: Department of Agriculture.
- Singh, L.** 1980. Prevalent practices of mixed cropping and cropping systems of pulse crops in India. *Indian Journal of Genetics and Plant Breeding* 40(A):11-15.
- van der Maesen, L.J.G.** 1980. India is the native home of the pigeonpea. Pages 257-262 in *Liber gratulatorius in honorem H.C.D. de Wit* (Arends, J.C., Boelema, G., de Groot, C.T., and Leeuwenberg, A.J.M., eds.). Miscellaneous papers 19, Wageningen, Netherlands: Landbouwhogeschool.
- van der Maesen, L.J.G.** 1986. *Cajanus* DC. and *Atylosia* W.&A (Leguminosae). Agricultural University Wageningen papers 85-4(1985), Wageningen, Netherlands: Agricultural University.
- Wallis, E.S., Byth, D.E., and Whiteman, P.C.** 1981. Mechanized dry seed production of pigeonpea. Pages 51-60 in *Proceedings of the International Workshop on Pigeonpeas*, 15-19 Dec 1980, ICRISAT Center, India. vol. 1. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Wallis, E.S., Faris, D.G., Elliot, R., and Byth, D.E.** 1986. Varietal improvement of pigeonpea for smallholder livestock production systems. Presented at the Workshop on Crop-livestock Systems Research, 7-11 Jul 1986, Khon Kaen, Thailand. Los Banos, Laguna, Philippines: International Rice Research Institute.
- Whiteman, P.C., and Norton, B.W.** 1981. Alternative uses for pigeonpea. Pages 365-377 in *Proceedings of the International Workshop on Pigeonpeas*, 15-19 Dec 1980, ICRISAT Center, India. vol. 1. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Willey, R.W.** 1985. Evaluation and presentation of inter-cropping advantages. *Experimental Agriculture* 21:119-132.